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Box 3
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SAMPLED VIDEO TECHNIQUES
for Processing and Narrow-Band Transmission*

by Glen R. Southworth
Colorado Video, Incorporated
Boulder, Colorado

How would you like to buy photocells, 5000 for a dollar, with these devices coming in a highly compact package and having low-cost interconnections? This is essentially what you do when you purchase a vidicon tube, though you may pay somewhat extra for infrared, ultraviolet, or X-ray spectral sensitivity.

The television camera is potentially one of the most useful, and certainly one of the most neglected instruments in the field of research and industrial process control. Typical advantages of TV as a data acquisition device are:

1. Compactness
2. Relatively low cost
3. Multi-spectral sensing capability
4. High sensitivity
5. "Real-time" operation, and
6. A wide variety of cameras and support equipment, such as signal distribution, test, recording, and processing devices are available.

Why isn't the television camera widely used in research laboratories and on the production line? Promises were made over 15 years ago that the newly introduced vidicon tube would generate an industrial market in the hundreds of millions of dollars, but this simply has not happened as of 1970. In guessing the reasons for this, perhaps the entertainment background of most television equipment development has led many scientists and engineers to regard this section of technology as trivial. Secondly, the most obvious application of television is the electronic transmission of images and it turns out to be expensive to use this expedient as a means of eliminating the necessity of stepping out of your office and walking down the hallway, and it is quite expensive when it comes to even crosstown picture transmission.

How about applications where distance is not a consideration, the research laboratory or production line? The typical television camera certainly does have some limitations. For example:

1. Resolution may be limited to as low as 500 x 500 picture elements for a given field of view.
2. Edge-to-edge shading in the field of view may be substantial.
3. Signal-to-noise ratio of the video signal may be poor.
4. The geometric accuracy of the scanned image may be substantially degraded.
5. The data rate of the camera output may be different from that desired.

*Presented at the SPSE Symposium on electronic imaging systems, April 1970.

The first four of the above limitations are perhaps nothing to brag about as compared to other scanning or sensing techniques, but can certainly be lived with in a very wide variety of applications. The video data rate is an entirely different story, however, with the essential problem being an extreme embarrassment of riches, for even the cheapest television camera can put out the equivalent of 60 million bits per second, a volume of data difficult or impossible to convert and process with current computing equipment.

This brings us to the main thesis of this paper: The combination of high data rates, the timed format of the signal, and information redundancy make video an ideal candidate of the use of sampling technology.

Data compression ratios of 1,000:1 are very easily achieved with high accuracy through use of a technique at least ten years old. In this case, horizontal drive pulses from the television camera are used as an initial timing reference to produce delayed sample pulses which can be located at any position in the TV raster. A simple sliding pulse generator producing 1 sample per TV line will give an output data rate of 15,750 points per second from a standard broadcast-type video signal. Typically, these samples form a vertical "row" on the TV raster, and such a row may be statically positioned or scanned from left to right (or right to left) to read out an entire frame of video information at a very low rate. Depending upon the horizontal resolution requirements of the image processing, a new frame rate of perhaps as low as 3 seconds for 180 x 250 picture elements up to 30 seconds for 500 x 900 picture elements may be produced. Of course, even shorter or longer frame times may be utilized for special applications.

With present-day circuitry, grey scale reproduction of the sampled video can be very accurate as well as resolving input video components up to 30 megaHertz and beyond. Although the one sample per TV line is probably the easiest to implement, higher order sampling is readily accomplished either to increase or decrease the system output data rate.

In an extreme case, double sampling may be used to select a single picture element out of the entire TV raster for analysis of relative brightness or for very slow scanning out of a single television line or portion thereof. This expedient makes possible both chart recording of video wave-forms and also time integration of unwanted noise components, thus providing a great increase in effective system sensitivity.

Our first illustration is a television display produced by a commercially available sampling instrument. The vertical white line in the center of the image represents a row of samples at a rate of 1 sample every television line, while the horizontal line is derived from a second sampler which operates at a rate of either 60 or 30 points per second, giving a DC readout from the video information occurring only at the cross section of the two lines. On the left-hand side of the screen, pulse position modulation is used to actually display the output of the first sampler as a video waveform superimposed on the screen in 1:1 correspondence with the actual picture.

In this particular instrument, the Z-axis conversion accuracy is on the order of 1%, while amplitude resolution is better than 1 part in 1,000. Spatial resolution is equivalent to one television line vertically and 30 megaHertz horizontally. The two sampling pulses are voltage-controlled as to position on the TV raster and have a voltage-to-time conversion accuracy of better than 1%.

This device is primarily intended for research and industrial applications and allows very detailed analysis of "stationary" video signals, particularly where low amplitude information must be extracted from noise. The device also provides a simple and accurate means of measuring the vertical resolution characteristics of a television camera, with either interlaced or non-interlaced scanning format.

Point sampling also provides what may be the only practical means of making dynamic noise measurements of video signals, an important factor in assessing the performance of image orthicon or isocon-type tubes wherein noise is a function of return beam current and, consequently, has a decided

differential characteristic. The crosshairs representing the X and Y sampling axes may also be manually or automatically positioned to provide X and Y coordinate analysis of significant picture elements and, of course, the low rate video output signals generated by the sampling process are easily digitized for computer data processing.

General applications of video data sampling can involve the analysis of subject brightness, area, height, width, and position, as well as intervals between targets and angular measurements. Similarly, the television camera may be used as an input transducer for curve analysis, while variations of sampling allow simple detection of either point or area target motion. To date, some of the specific applications of video sampling have included: Biomedical image scanning, TV pupillometry, analysis of blood cell clumping, X-ray and nuclear image analysis, blood vessel diameter measurement, target displacement in successive video frames, solar flare analysis, IC mask inspection, speedometer calibration, neon lamp testing, plasma panel checkout, analysis of SEC vidicon and plumbicon sensor performance, hole diameter measurements, and many more. Thus, it might be inferred that the area of application of video plus sampling is very large indeed, particularly when combined with computer data processing.

As stated at the beginning of this paper, a second factor of significance in the non-utilization of television is the cost of transmission of video signals. Again, sampling technology can play a very important role in making both medium and long-distance communications an economic practicality. The key factor is high quality bandwidth compression, providing video data which may be transmitted over leased communications circuits or through the standard dial-up telephone network. Commercial equipment is available in this category and a block diagram of the CVI Model 201A illustrates the general principles involved in a communications sampling converter.

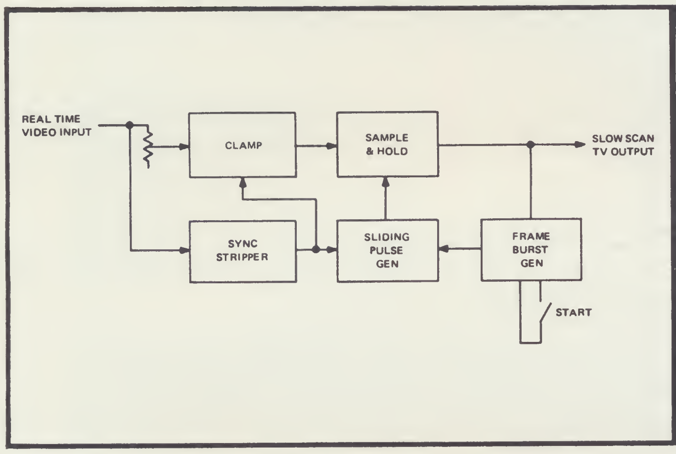
Although bandwidth compression is readily achieved with high accuracy and relatively low expense, in a majority of communications applications it is desirable to produce a "soft copy" bright display of the transmitted information. Again, standard television format has many advantages, including the availability of a wide range of low-cost monitors, both monochrome and color, use of local signal distribution and handling, use of the video tape recorder for temporary information storage, and the availability of large-screen television projectors for group viewing.

A variety of expedients may be used for the end display of narrow-band video images, including rapid photographic processing, direct-view storage tubes, and scan converters utilizing electrical in/electrical out storage tubes. A very promising area of technology, however, is the magnetic disc memory which allows much of the technology in the initial sampling bandwidth compression system to be used in re-creating standard television images, and Figure 3 shows a block diagram of the CVI Model 220A, a communications instrument of this nature.

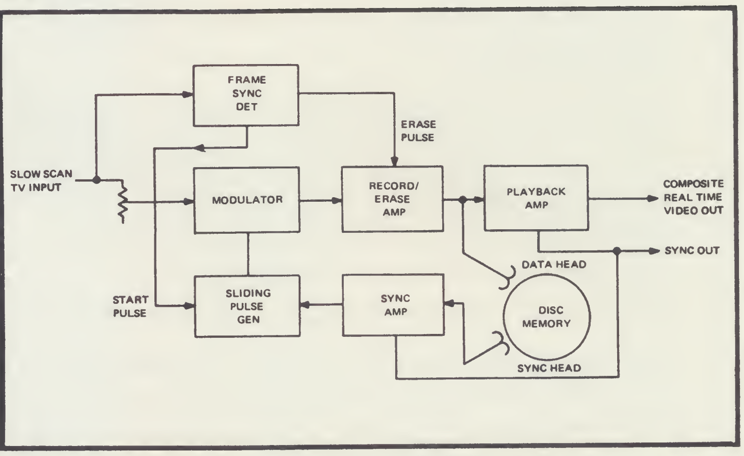
Examples of overall system quality are shown in the following illustrations. The first of these has a resolution of approximately 400 x 500 picture elements and required 15 seconds transmission time at a bandwidth of 8 kiloHertz. The second image of the same resolution, but required 1 minute 40 seconds of transmission time with a bandwidth of 1 kiloHertz, adequate for most voice-grade transmission facilities.

The magnetic memory is of particular value where multiple image storage is of concern, inasmuch as it is quite practical to store several hundred separate images on one side of a disc. Color transmission is also readily accomplished by either sampling the RGB outputs of a conventional color television camera, or simply sequentially placing appropriate filters in front of the lens of a conventional black and white camera.

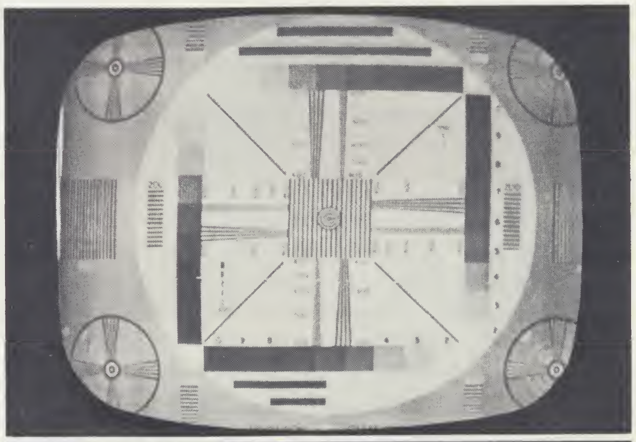
To date, sampled video data transmission has been used in a number of applications including corporate communications, teaching of graduate engineering courses, signature verification in banking, military communications, fire detection, engineering conferencing, remote computer data input, and intrusion detection. Many other uses have been discussed, and it is felt that in the future this aspect of technology may have a strong influence on the field of graphic communications.

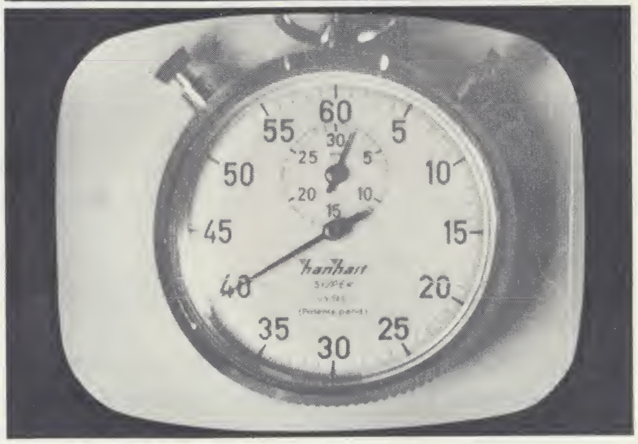


REAL TIME
VIDEO INPUT
CLAMP
SAMPLE
& HOLD
SLOW SCAN
TV OUTPUT
SYNC
STRIPPER
SLIDING
PULSE
GEN
FRAME
BURST
GEN
START



FRAME
SYNC
DET
ERASE
PULSE
SLOW SCAN
TV INPUT
MODULATOR
RECORD/
ERASE
AMP
PLAYBACK
AMP
COMPOSITE
REAL TIME
VIDEO OUT
SYNC OUT
DATA HEAD
START
PULSE
SLIDING
PULSE
GEN
SYNC
AMP
DISC
MEMORY
SYNC HEAD





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short form catalog

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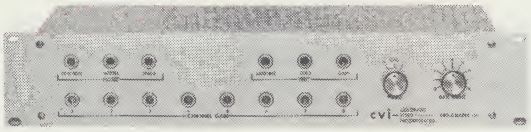
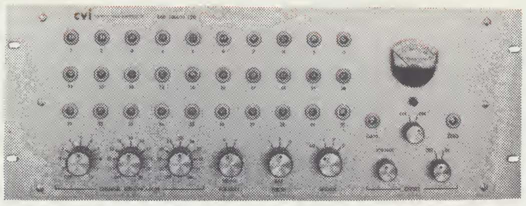


Bar Graph 101

A device accepting 8 negative going signal inputs and converting these into a vertical "Bar" pattern as seen on the screen of a standard TV monitor. Requires external sync. Rack mount, 3½" high, solid state.

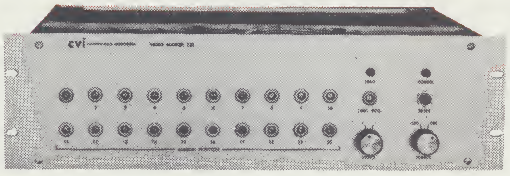
$1250.



Bar Graph 120

Accepts 30 negative going input signals and produces a horizontal bar display with better than 1% accuracy. Has individual channel markers, zero suppression, decade expansion, and other features. Requires external sync. Rack mount, 7" high, solid state.

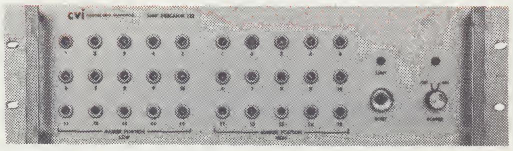
$4200.



Video Marker 121

A unit generating 20 individually moveable vertical lines as seen on the screen of a TV monitor. May be used for the display of linear or non-linear scales, or as an electronic "grease pencil." An additional marker sets a limit position, tripping an alarm when video falls within a restricted area. Requires external sync. Rack mount, 5¼" high, solid state.

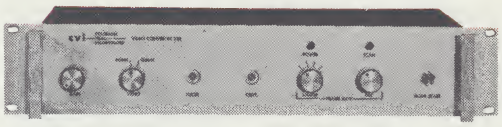
$2800.



Limit Indicator 122

A device producing 15 separate "high" and 15 separate "low" vertical markers with automatic alarm when video falls outside of predetermined limits. Requires external sync. Rack mount, 5¼" high, solid state.

$3500.



Video Converter 201

A unit which accepts a standard "real time" television input signal and uses high speed sampling to produce a "slow-scan TV" output signal for computer data reduction or other forms of video processing. Conversion accuracy is excellent, with negligible grey scale distortion. Also contains simple "Two Level" quantizing circuits giving 1 bit binary output signal. Rack mount, 3½" high, solid state.

$1950.

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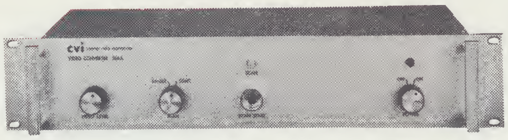
Video Converter 201-A



Communications version of the model 201. Incorporates sync stripper, frame burst generator, and continuous scan circuitry, but does not have quantizer. Rack mount, 3½" high, solid state.

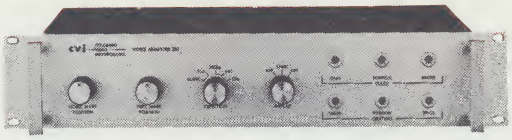
$1950.

Video Converter 220-A

Companion unit to the 201-A. Utilizes a magnetic disc memory together with high speed pulse circuits to convert "slow-scan" video or properly formated computer data to standard 525 line TV rates. Has automatic erase and indefinite image storage capabilities. Options include color reproduction and selective record/erase. Rack mount, 7" high, solid state circuitry.

$5000.

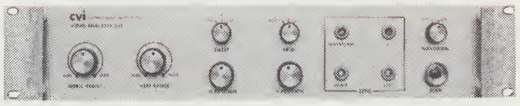
Video Analyser 301



An instrument displaying "vertically line-selected" TV waveforms directly on the screen of a normal TV monitor. 1/1 waveform/picture ratio simplifies identification of individual picture elements. Display also includes an electronic reference grating and H and V markers. Requires external sync. Rack mount, 3½" high, solid state.

$875.

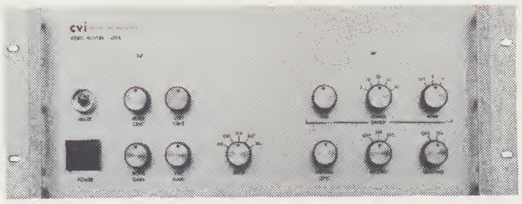
Video Analyser 321



Laboratory version of the 301. Incorporates additional circuitry to allow chart recording of "line selected video waveforms, X-Y coordinate indication, noise analysis, computer data input, and other features. Requires external sync. Rack mount, 3½" high, solid state.

$2500.

Video Plotter 401-A



An instrument which converts low frequency data to video format with indefinite signal storage via a wide band magnetic disc memory. Features include internal time base, electronic reference grating, multimode recording, grey scale reproduction, and selective erase. Generates own sync. Rack mount, 7" high, solid state circuitry.

$4000.

Video Memory **404-A**

A wide band magnetic disc recorder accepting properly formatted computer output signals for conversion to standard 525 line TV rates. Incorporates four separate read/write/erase channels for generation of multiple displays or synthetic color. Also produces H and V timing pulses for synchronization of auxiliary equipment. Rack mount, 8¾″ high, solid state circuitry.

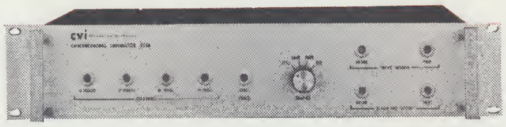
$6000.

Data Camera **501**

A Vidicon camera intended for laboratory use. Features both "real time" and "slow-scan" video outputs for computer data reduction. Requires external sync. Control chassis is rack mount, 3½″ high, solid state.

$3500.

Sync Generator **601-B**



A unit intended for laboratory use when either standard or nonstandard TV scan rates are required. Uses micrologic binary counters with adjustable feedback paths. Drive and blanking pulses are variable width, but sync is not EIA format. Incorporates dot/bar generator for test purposes. Rack mount, 3½″ high, solid state.

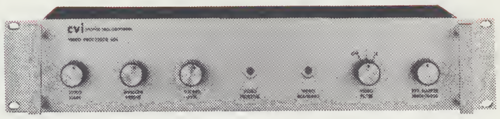
$1025.

Data Insertion Generator **603-A**

Combines the functions of a 2 channel video mixer, special effects generator, and video pointer. Moveable oblong is positionable to any point in TV raster and is variable in size over a wide range. Oblong acts as the internal "key" in special effects mode, and also generates a white "box" outline or solid square for marking purposes. Requires external sync. Rack mount, 3½″ high, solid state.

$1500.

Video Processor **604**



An instrument which modifies the grey scale of a video input signal by selecting and amplifying a variable width "slice." Also incorporates variable brightness control, sync adding, and marker adding functions. Requires external sync. Rack mount, 3½″ high, solid state.

$950.

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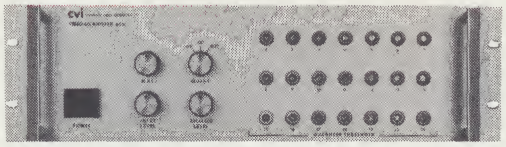
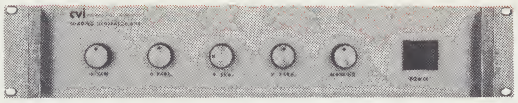


Video Quantizer 606

A device which allows the processing of a video input signal into 16 separate amplitude levels. Operates with tape, camera, or disc inputs and allows radical grey scale alterations or the generation of complex synthetic color signals. Rack mount, 5¼″ high, solid state.

$3500.



Shading Generator 608

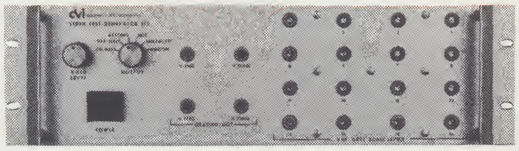
Generates H and V sawtooth and parabolic waveforms of variable amplitude and polarity to provide compensation of brightness errors in video input signals. May also be used to drive external dynamic correction circuitry. Requires external sync. Rack mount, 3½″ high, solid state.

$950.

Video Pointer 610-C

A voltage positionable marking device producing a set of cross-hairs, solid oblong, "box" outline, or a combination of these. Rack mount, 3½″ high, solid state. Requires external sync.

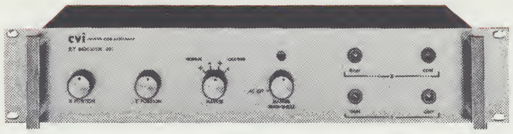
$1950.



Video Test Generator 615

Produces various test signals including: 16 step linear grey scale, 16 step variable grey scale, grating, dot, multiburst, and window patterns. Requires external sync. Rack mount, 5¼″ high, solid state.

$1500.



X-Y Indicator 621

An instrument intended to reduce spatial data coordinates in a TV image to two variable X and Y voltage outputs. Either a dot or cross-hair marker is manually positioned to any location in the TV raster. Accuracy is better than 1%, and an internal grating generator allows convenient camera setup. Rack mount, 3½″ high, solid state.

$1500.